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Genetic diversity for drought resistance in wild emmer wheat, *Triticum dicoccoides*.

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ABSTRACT

Wild emmer wheat, the tetraploid progenitor of cultivated wheat, is a potential source for various agronomically important traits, including drought resistance. In this study, 111 accessions of wild emmer wheat and three durum wheat cultivars were examined under two irrigation regimes, well-watered (500 mm) and water-limited (250 mm). A wide variation was found among the wild wheat accessions for all the examined traits. A considerable number of the wild emmer accessions exhibited an advantage over their cultivated counterparts under both treatments in terms of total dry matter, spike dry matter and relative (dry/wet) total dry matter. An interesting genotype x environment interaction was evident in the carbon isotope ratio (an indicator of water use efficiency). In the well-watered treatment the cultivated controls exhibited carbon isotope ratios comparable to the highest values (=high water use efficiency) of the wild accessions, whereas in the water-limited treatment they fell in the intermediate levels of the wild accessions. These results suggest that wild emmer wheat may offer the potential to improve drought resistance of durum wheat. The associations between drought resistance and eco-geographical data of the collection sites indicate that wild emmer populations from arid environments can offer a high potential to improve drought adaptation of cultivated wheat

INTRODUCTION

Developing genetically drought resistant crop plants is a major strategy of alleviating future threats to food security in a demographically exploding world (Plucknett et al., 1987).
This solution, however, requires a comprehensive exploration of potential genetic resources and an in-depth understanding of their adaptive mechanisms and responses to water stress. The most promising source for novel genes and alleles to improve drought resistance of cultivated crops are their wild relatives and progenitors. Israel and vicinity is the center of origin and diversity of wild emmer wheat (*Triticum dicoccoides* Körn.) (Nevo, 1998; Nevo et al., 2002). This tetraploid (AABB) wild species is fully compatible with the durum wheat (*T. durum* Desf.) and considered to be the progenitor of both durum and bread wheat (*T. aestivum* L.). Wild emmer wheat thrives across a wide ecogeographic range including desert environments, and hence it may offer the genetic diversity required for improving drought resistance of wheat (Nevo et al., 2002). In this study we aimed to explore and characterize the genetic diversity for drought resistance in wide collection of wild emmer wheat.

MATERIALS AND METHODS

A collection of 111 of wild emmer wheat accessions as well as 3 durum wheat control cultivars (Inbar, Svevo and 580D) were examined in Israel during the winter of 2001-2002. The wild emmer wheat accessions consisted of 25 populations with 2-5 accession per population. These populations collected in Israel, represent a wide range of environmental conditions, such as altitudes of -30-800 m, average annual rainfall of 230-800 mm and various soil types. Plants were grown in a rain-out shelter under two irrigation regimes, well-watered control and water-limited (termed hereafter as "wet" and "dry", respectively). The wet treatment was irrigated weekly with a total amount of about 500 mm, whereas the dry treatment was irrigated every other week with a total amount of 250 mm. Each treatment was replicated 6 times using a split plot design with irrigation treatment in main plots and a single plant as a sub-plot. Germplasm characterization included plant productivity (total dry matter and spike dry matter, both in absolute and relative [dry/wet] terms), plant height, carbon isotope ratio ($\delta^{13}C = {}^{13}C/{}^{12}C$); and indicator of water use efficiency (= total dry matter produced / water used), osmotic potential, and plant phenology (time of heading and maturity).

RESULTS AND DISCUSSION

An analysis of variance of most measured traits indicated that the variation between genotypes within populations was significant, therefore, the data was further analyzed and interpreted on a genotype basis, rather than on a population basis. These results indicate that populations of which specific accessions have shown a potential for drought resistance warrant further exploration to identify the genotype with the highest potential.

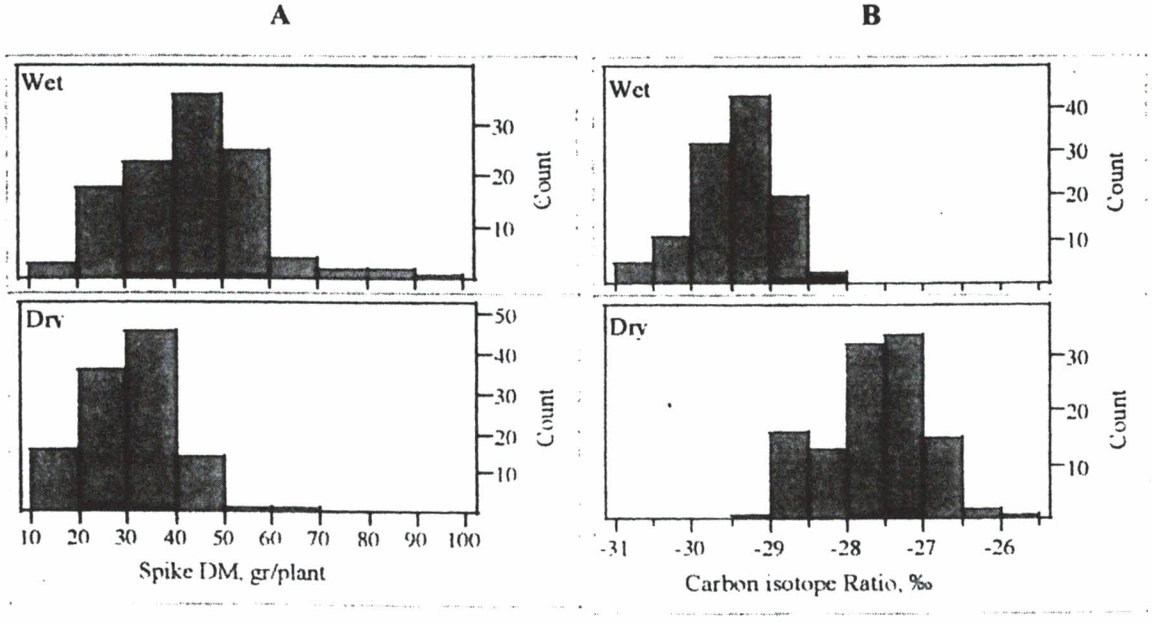

Figure 1. Distribution of two selected traits, spike dry matter (A) and carbon isotope ratio (B), of wild emmer wheat and cultivated durum wheat (marked in black within the histograms) under water-limited ("dry", 250 mm irrigation) and well-watered ("wet", 500 mm irrigation) treatments.

A wide variation was found among the wild wheat genotypes under both treatments for all the traits examined (selected traits shown in Fig. 1).

Most of the wild emmer accession produced a greater total dry matter than did the cultivated control species. Even spike dry matter, which was expected to be higher in the cultivated species as a results of their domestication and breeding, was comparable to the intermediate levels produced by the wild emmer wheat (Fig. 1A). A considerable number of the wild accessions exhibited an advantage over their cultivated counterparts also in terms of relative productivity (dry productivity/wet productivity). An interesting type of genotype X environment interaction was evident in the carbon isotope ratio (Fig. 1B). In the "wet" treatment the cultivated controls exhibited $\delta^{13}C$ comparable to the highest values (=high water use efficiency) of the wild accessions, whereas in the "dry" treatment they fell in the intermediate levels of the wild accessions.

The advantage of wild accessions over the cultivated controls in terms of absolute productivity (total dry matter or spike dry matter) can be derived from a greater competitiveness that will not necessary be expressed in a dense homogenous crop canopy, or due to the later flowering observed in the wild accessions. However, the advantage of the wild emmer accessions over the cultivated controls in relative terms or in $\delta^{13}C$ under the dry treatment, are most certainly a result of the drought resistance of the wild accession. These results suggest that wild emmer wheat has a high potential to improve drought tolerance of the cultivated durum wheat.

The associations between drought resistance parameters and eco-geographical data of the collection site were analyzed by correlation analysis. The number of hot days (Tmax>30C) in spring (March-May), or alternatively the number of hot dry days (Tmax>39C, RH<25%) in spring, correlated positively with harvest index ($r=0.8$), spike dry matter ($r=0.63$) and relative total dry matter ($r=0.51$), and negatively with the vegetative dry matter ($r=-0.52$) and time to heading ($r=-0.77$) (all correlation coefficients are significant, $p<0.05$). These results indicate that wild emmer populations from arid environments can offer a high potential to improve drought adaptation of cultivated wheat.

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